THE PSYCHOLOGICAL EFFECTS OF OXYGEN DEPRIVATION

ENGLISH BAGBY

A DISSERTATION

Submitted to the Board of University Studies of the Johns Hopkins University in conformity with the requirements for the degree of Doctor of Philosophy

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REPRINTED FROM THE JOURNAL OF COMPARATIVE PSYCHOLOGY,
VOL. I, No. 1, pp. 97–113, 1921

Reprinted from THE JOURNAL OF COMPARATIVE PSYCHOLOGY
Vol. I, No. 1, February, 1921

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On October 18, 1917, The War Department authorized the appointment of a Medical Research Board "to investigate all phases of flying which bear direct relation to the mental and physical equipment of the flier." Almost the first problem which came to the attention of the Board was the classification of all army aviators according to their fitness for altitude work. From considerations of convenience and simplicity, it was immediately decided to use a form of the Henderson Rebreathing Apparatus,[2] which supplies the most deleterious feature of increasing altitude, namely, decreasing oxygen tension.

The preliminary investigation of the psychological effects of low oxygen tension in rebreathed air, and the development of a standard test for resistance, was entrusted to Major Knight Dunlap and two assistants, Lieutenant Schachne Isaacs and Lieutenant English Bagby.

I. PRELIMINARY STAGE OF THE INVESTIGATION

The standard psychological test had to be adapted to certain limitations imposed by the military emergency and by the conditions of rebreathing:

1. Since it was considered imperative that all aviators be very promptly classified, it was necessary to limit the time of each complete psychological examination to approximately thirty minutes. This precluded a lengthy period of practice in the test-

[1] Authority to publish granted, March 16, 1920, by Board of Publication, Surgeon General's Office.

[2] A description of the Henderson Rebreathing Apparatus is to be found on page 169, "Air Service Medical."

performance previous to the rebreathing examination. On the other hand an examination-procedure involving significant effects of practice was regarded as impractical, since the improvement incidental to practice might be expected to obscure any possible deterioration due to oxygen depletion.

2. It was thought inadvisable to use graphic registrations of performance. In the first place considerable time is required for record reading and statistical treatment. There is a second, and more serious, objection: while errors may be readily registered, compensatory reactions by which errors are avoided cannot be conveniently recorded.

3. It was necessary that the test-performance be non-fatiguing as low oxygen effects and fatigue effects are liable to confusion.

4. In order to have some constant check on the physical condition of the subject, pulse and blood-pressure readings must be made at two-minute intervals throughout the examination. This eliminates the use of the left hand in the psychological work. In addition, the fact that the subject was required to grip the mouth-piece of the rebreathing machine with his lips and teeth precluded the use of any psychological test involving a verbal response. From this it will be seen that the subject's responses were limited to one hand and his two feet.

In view of the absence of pioneer work on the problem it was necessary to face the possibility of deterioration, or change, in any of the psychological functions. Consequently the tests which were first tried involved practically all varieties of mental activity: Sensitivity, Muscular Control, Emotions, Memory, Attention, and the more complex processes.

It was the custom in the early work to vary the quantity of air to be rebreathed in such a way as to provide sufficient for any desired length of "run" from fifteen to forty minutes. When required for special purposes, oxygen was introduced into the reservoir and the run prolonged indefinitely. The method of introducing oxygen was also used in controls: when a given test performance was found to deteriorate in successive trials, oxygen was supplied without the subject's knowledge and observations were made on the performance as it returned to normal.

In the earliest stage of the investigation, almost every subject was permitted to faint before being removed from the machine. Later, as the symptoms of impending collapse became more familiar, the subject was released while still conscious.

It did not seem practical to make a systematic study of each mental function. Instead, it was determined to use selected tests to discover which functions were most impaired by oxygen deprivation. With this information, an intensive study of these specific functions was to be undertaken.

Description of the preliminary tests

The psychological tests listed below were given at three-minute intervals throughout a number of "runs" and the performance was studied for evidence of deterioration or change. No effort was made towards absolutely accurate determinations since the early tests were used simply with the purpose of obtaining indications for further work. The quantitative results of the test do not constitute the sole source of information. Much data was also secured through incidental observations and the subject's description of his experience.

1. Sensory tests. (a) Vision (lower threshold of visual acuity). The apparatus consisted of the Ives visual acuity test object, as made by Bausch and Lomb Optical Company. It was found that the commercial form of the Ives instrument is not well adapted to research, the scale of adjustment being too coarse. Another objection to the test as given was found in the fact that acceptable settings for all subjects, even under normal air conditions, varied between very wide limits. The use of special statistical methods is of little avail because of the small number of readings which can be gotten during a standard "run."

With this test, as with all others that were used, there was found to be a short period, just previous to the final collapse, during which the performance was unmistakably less efficient than under normal air. This period involves, not simple deterioration in a sensory function, but a partial failure of "voluntary attention," with inability to cooperate fully. Effort is more or

less spasmodic, and a dazed attitude follows any unexpected stimulus. This period, technically known as the *final stage of asphyxiation*, persists for an interval of from fifteen to ninety seconds, occasionally longer.

Coincident with, or immediately following, the beginning of the profound psychological disturbance, a failure of physiological compensation occurs. It is marked by a failing vascular tone. In the close association of the psychological "break" and the failure of physiological compensation, there is some support for the conception of the psychological processes as integrative, i.e., as dependent on the integration of the central nervous system, rather than on the action of specific parts of the system.[3]

(b) Audition (lower threshold of auditory acuity, and threshold of pitch discrimination). To determine the lower threshold of sound intensity, Dunlap's acoumeter was used. This instrument consists of a vertical metal reed (256 d v), the upper end of which may be drawn from the vertical position to any desired position by an electro-magnet. When the current through the magnet is broken the reed is releasd and vibrates. Since the position of the core of the magnet may be varied, any desired amplitude of vibration can be secured by adjustment of a millimeter scale attached to the magnet-core.

No deterioration in the performance on this test was observed before the final stage of asphyxiation, the stage of failure of voluntary attention described above. Also it was found that slight sounds arising from the necessary manipulation of the rebreathing machine, and other incidental noises, were sources of distraction tending to invalidate the results.

An effort was made to use the difference threshold of pitch as an index of deterioration but the results were negative.

(c) Pressure (reaction time to change of pressure). All fliers testify to the importance of sensations of pressure arising from the buttocks and the posterior surfaces of the thighs. These sensations, together with visual cues and afferent processes from the inner ear, are involved in leveling and properly banking a plane.

[3] See Dunlap: An Outline of Psychobiology, 2 ed., p. 122.

For testing purposes a special apparatus was devised by Major Dunlap. It consisted of a large solenoid magnet, to the core of which was attached an upright brass rod surmounted by a horizontal plate. The subject's left thigh was placed upon this plate and the weight forced the core from its resting position in the magnet. A certain amount of upward pressure was thus exerted against the surface of the leg and this pressure could be increased or decreased by changing the intensity of the current flowing through the coil.

The apparatus control was not sufficiently good to permit of the establishment of adequate thresholds.

2. Motor performance tests. The tests selected involved a minimum of discriminatory attention. Deterioration, due to low oxygen tension, affects the speed of movements, and causes tremor, incoordination and over-discharge.

(a) Aiming (steadiness). Dunlap's modification of the Whipple arrangement was used. This consists of graded openings in a metal plate, and a stylus. An attempt was made to find the smallest opening in which the stylus could be held for twenty seconds without contact. Trials were made at intervals during the process of asphyxiation.

It was found that there is a constant, but irregular, decrease in steadiness during the *preliminary stage of asphyxiation.* This stage extends from the time of the appearance of the first effects to the beginning of the *final stage of asphyxiation.* In 272 standard examinations, with the most favorable conditions of observation, the earliest appearance of psychological deterioration was in the seventh minute, or at an oxygen tension of approximately 17.3 per cent (0.73 per cent of the 272 cases).

The aiming test was not available for use in the standard examination because breathing is seriously interfered with by the tendency of the reactor to hold his breath during the trial. This tends to aggravate the effects of low oxygen tension.

(b) Tapping (rapidity of motor discharge). A special form of the tapping test was used. The apparatus consisted of the usual form of stylus, and two mounted brass plates (2 by $2\frac{1}{2}$ inches), separated by a narrow piece of hard rubber. The plates are

touched alternately. The advantage of this arrangement over the usual form rests in the fact that greater motor control is required and tremors are less likely to be registered as taps. Each trial lasted fifteen seconds and the number of taps electrically recorded, was taken as the record of the performance.

The number of taps made during each fifteen-second interval remained fairly constant until the final stage of asphyxiation, at which time marked muscular incoordination appears. During the preliminary stage of asphyxiation there is a significant increase in the energy of the taps. It has been suggested that the rate of tapping is maintained by this increase of energy. However, the energy-increase appears to be a true low-oxygen effect rather than a compensation phenomenon.

(c) Knee-jerk (irritability). A rubber hammer, hanging freely on a pivot, was permitted to fall against the sensitive point of the subject's knee from various heights. In this way the threshold of irritability was established. The results were extremely variable but showed no indication of decreased irritability during asphyxiation.

3. Memory tests. Three forms of memory tests were used with immediate or delayed recall.

(a) Series of from five to nine consonants were orally presented and the subject was required to reproduce them in writing. The material used is shown below.

RKZWT
CXWNFZ
JLXBRVN
NHBDZVCR
VJSRBLTMW
HRKGWMDPTL
ZXWDKTNVSHQ
YPCQDKWZMTBJ

(b) Combinations of color names and numbers were orally presented for reproduction. Selections were made from the following list.

White	63	Ecru	81
Russet	84	Black	52
Gray	47	Green	24
Amber	28	Lilac	73
Violet	96	Orange	35
Red	58	Blue	74
Tan	14	Buff	29
Gold	85	Rose	95
Azure	46	Drab	62
Yellow	69	Purple	79
Scarlet	57	Crimson	13
Straw	25	Slate	68
Brown	18	Pink	37
Lavender	36	Indigo	92

The performance was rated on the number of combinations which could be correctly reproduced.

(c) Memory of position. The apparatus consisted of forty-nine miniature lamps arranged in rows of seven, and mounted on a vertical black board. A scattered group of from three to seven lamps were lighted for three seconds and the subject was instructed to designate on a chart the position of the lamps which had been lighted.

The phenomena of immediate and delayed recall were investigated with these three tests. No deterioration was found under low oxygen tension during the preliminary stage of asphyxiation. However, it was noted that material presented during the final stage of asphyxiation was not properly impressed (perceived). Nothing specific can be said about retention during this stage.

4. Attention tests. Deterioration in attention may take the form of confusion between stimuli, failure to react, diminution of attention-range, or distractibility. The following tests were used:

(a) Serial reaction. The apparatus was a serial reaction board consisting of twenty-four minature lamps, with corresponding switches, in a semi-circular arrangement. The series is started when the operator lights a lamp. The subject reverses the corresponding switch, extinguishing the first lamp and lighting a second, and so on to the end of the series. The wiring is so arranged that the lamps are lighted in irregular order, and the se-

quence is changed after each trial. The time of the series of reactions is taken with a stop-watch.

Low oxygen tension does not seem to affect the speed of the performance until the final stage of axphyxiation is reached. However, as noted in the tapping test, the reaction movements become progressively more energetic during the preliminary stage of asphyxiation.

(b) Addition (Dunlap's material). This test involves the use of sheets containing sixteen lines of digits, each line containing forty-five digits. A single line was presented to the subject with instructions to add the digits from left to right until the sum equalled or exceeded some designated number (12, 13, 14, or 15). After the last number of a group a line is drawn by the subject, and the difference between the total and the designated number is inserted.

No low oxygen effect was observed before the final stage of asphyxiation.

(c) Tactile discrimination. The subject was required to sort cards containing diamond shaped openings. Time was taken for a series of fifty cards.

The results were entirely negative.

Summary

This completes a review of the tests which were used to determine the general character of the psychological effects of oxygen deprivation. The results of this preliminary work may be briefly summarized. The summary includes, not only the observations made on test performances, but such additional data as was secured through self-observations and incidental observations made by the experimenters.

1. Motor performance. The most obvious effect of subjection to a gradually depleted oxygen supply is the production of tremor, muscular incoordination, and over-discharge. These effects become progressively more pronounced as rebreathing proceeds, and is presumably related to a less and less complete integration of the central nervous processes.

2. Attention phenomena. Low oxygen tension tends to bring about a reduction in the ability to carry on a number of discrete tasks simultaneously through rapid shifting of attention. This restriction of the general field of attention operates in such a way as to lower the subject's distractibility. Hence the attention directed to a simple, relatively mechanical, feature of a complex task is superior to the attention given to that feature under normal air conditions. It is probable that the absence of low-oxygen effects in the simple sensory and motor tests, used in the preliminary investigation, is largely accounted for by the progressive decrease of distractibility.

In the final stage of asphyxiation the subject is unable to concentrate on any task in the normal way, and instructions have to be given insistently and in a loud voice.

3. The condition of resting muscles. Some data was secured through observation of the condition of the musculature of the left hand during various stages of the run. The muscular condition, normally firm, was found to become first relaxed, then tense, and finally twitchy.

4. Removal of inhibitions. In the final stage of asphyxiation some subjects give expression to uncontrolled anger. Occasionally an attempt is made to break various parts of the apparatus or the mouth piece is vigorously expelled. In milder forms of the condition an attitude of resentment is taken toward all stimuli which are presented.

On the other hand some subjects become silly, winking and smiling at the apparatus and at the experimenter. Sometimes this is followed by uncontrollable laughter, which necessitates removal from the machine.

Such conduct represents a primitive, or emotional, form of behavior, with a removal of inhibitions. The phenomenon is perhaps related to the factors involved in decreased distractibility, as previously described. The experimental conditions lose their restraining value.

5. Self-observation. Many subjects report that they are able to "pull themselves together" for any brief task but, upon its completion, "want to rest."

This fact was substantiated by direct observations made by the experimenters. In the latter part of the preliminary stage of asphyxiation, after a very normal performance on a short test, the subject may sink back into his chair with eyes closed and quite inert. He is with difficulty aroused for the next task but, when aroused, makes as good a performance as before. This is called the "spurt phenomenon."

Self-observations made during the final stage of asphyxiation are almost uniformly unreliable. When a subject is removed from the machine after repeated efforts to arouse him have failed, he may maintain that his work was efficient to the end. This occurs even when complete unconsciousness has not intervened.

The Standard Classification Test, as adopted by the Medical Research Board, is based on the considerations just listed. It involves a *continuous* performance to avoid the "spurt phenomenon," mentioned in no. 5. The motor performance is of such a sort that *decreased muscular control* is at once detected. It includes three discrete tasks so as to demonstrate *increasing restriction of attention*. The performance is clinically observed rather than graphically registered for the reasons mentioned in the discussion of the limitations imposed by the military emergency.

It is especially important to note that no claim is made that the standard test determines the constitutional resistance to low oxygen tension. The physiological condition of the subject at the time of the test may operate in such a way as to affect the performance profoundly. Loss of sleep, dissipation, and indigestion, are believed to modify constitutional resistance.

II. THE STANDARD PSYCHOLOGICAL TEST FOR RESISTANCE TO OXYGEN DEPLETION

In order to complete this account of the work on low oxygen tension, the following description of the apparatus, technique, and procedure of the standard test, is appended. The description, with minor textual corrections, is taken from the Manual of the Medical Research Laboratory, first edition, pages 170–177, as written by Major Knight Dunlap.

Apparatus for the standard test

The apparatus used for the psychological tests consists of two groups, (A) and (B).

A. This group includes a number of pieces assembled on a specially designed table, adjustable in height and slope, and swinging on a single heavy post mounted on a cast-iron base. This table is designed to furnish a sufficiently rigid mounting and at the same time giving greater convenience than could be afforded by a table with legs. The apparatus mounted on this table forms three separate units:

1. There are fourteen stimulus lamps (2 c. p.) arranged in two rows of seven each, with two similarly arranged rows of contact buttons, each surrounded by a washer. The contact buttons are rounded screw-heads of $\frac{1}{4}$ inch diameter. In addition, there is a check lamp and a red error lamp; and a stylus with a hard rubber handle and metal tip. These parts of the unit are so wired electrically that when a stimulus lamp lights, the corresponding contact button is "alive" and, if touched with the metal tip of the stylus, the check lamp is lighted. If the washer surrounding any of the buttons is touched with the metal tip of the stylus at any time, the error lamp is lighted.

2. Two ammeters mounted on a metal arm above the table top are connected in series with two rheostats, one on the upper side of the table top at the edge near the reactor, the other underneath, at the edge near the psychologist. One ammeter faces the reactor, the other the psychologist. A change in the resistance made by the psychologist at his rheostat, causing a change in the ammeter reading, may be compensated for by a change in the reactor's rheostat, by which the original ammeter reading may be restored.

3. A small electric motor mounted on the upper side of the table top is connected in series with a third rheostat underneath the table. A two-way lever switch mounted underneath the table at the edge next to the psychologist, and a rocking pedal two-way switch on the floor under the table, are connected with the rheostat by a three-wire system, so that a part of the resist-

ance of the rheostat can be cut out (thus increasing the speed of the motor) by either switch and again cut in (thus restoring the lower motor speed) by either switch.

B. The second group of apparatus, on a small table in any convenient part of the room, consists of an automatic distributor which lights the stimulus lamps in selective order and for a constant interval. During the examination a stimulus light appears every fifth second and remains for one and a half seconds.

Method of conducting the test

The rebreathing machine is adjusted by the physiologist to give a "standard run," which will vary in time according to the individual and his method of work, but which will bring a reactor of the highest type to 7 per cent oxygen in twenty-five minutes on the average. For this standard run the quantity of air in the reservoir at the start is 53 liters.

The reactor, being seated in proper position before the apparatus, is given the following instructions to read:

Instructions

Read carefully.

You have three things to do:

1. Lights

When a light flashes, touch with the stylus the top of the corresponding screw-head. Do not touch the washer.

2. Ammeter

Watch the ammeter and by adjusting the rheostat (using the right hand) keep the ammeter at the designated mark.

3. Motor

Keep the motor at low speed by maintaining the proper positions of the pedal. When the motor speeds up reverse the pedal and hold it in its new position until the speed again increases.

Notes

(a) The lights are of first importance, i.e., if a lamp lights when you are reacting (or are about to react) to the ammeter hand, react to the light first and then go back to the rheostat.

(b) When you touch with the stylus the contact-button corresponding to a light, the movement of the hand and arm should be "free" (neither hand nor arm should touch table, rheostat, or board). The hand may at other times rest on the slide of the rheostat.

(c) Do your work with *Accuracy, Neatness, and Promptness.* Do not bang, slam, or jab.

While the reactor is reading the instructions, the psychologist is ready to explain any detail of the apparatus or method in which the reactor may show special interest; and, after the reactor has finished reading, the psychologist further explains the procedure and verbally emphasizes the important points in the instruction.

When the rebreathing machine is ready and the blood-pressure recorder has secured the requisite preliminary readings, the mouth-piece and nose-clip being in place, the external opening of the mouth-piece is closed by the responsible clinician and the test commences. The psychologist and all others concerned in making the test start their stop-watches at this moment.

During the first three minutes of the test the psychologist coaches the reactor if necessary and estimates his comprehension of the task and instructions, his power of attention, and his composure (freedom of excitement or nervousness) entering the words good, fair, or poor, on his record sheet. He also notes the motor tendencies of the reactor as they fall into one or more of the following categories:

Motor tendencies

Tremor	Slow
Tense	Hesitant
Impulsive	Accurate
Steady	Inaccurate
Rapid	Restless

In addition to these general tendencies, it is important that the psychologist take notice of other specific tendencies shown by the reactor, and if definite types of error are shown, he must

watch during the succeeding five or six minutes for improvements. In this way the "M" and "A" determinations (described below) may be accurately noted as deterioration from the normal performance of the reactor, and not as failures with regard to an absolute standard of proficiency. This is important since the rating on these tests is valid only as an index of the effects of asphyxiation on a particular individual and not as an index of efficiency or inefficiency in any other respect. The comprehension, attention, and composure, and the motor entries are, however, worth recording for purposes other than oxygen rating.

Normally the test continues until the point of complete psychological inefficiency is reached, at which point the psychologist sharply notifies the responsible medical attendant in order that the reactor may at once be given air, and so prevented from undergoing complete collapse.

The recognition of "complete inefficiency" is a matter on which the psychologist must carefully train himself. In general it shows itself in a definite way, as described below, but may show in forms which are readily recognized by the trained observer but which are described with difficulty.

In many cases the medical attendant will find it necessary to interrupt the test, because of cardiovascular symptoms, before psychological inefficiency is reached.

At the start of the rebreathing examination it is advisable to allow the reactor to react to the lights alone during the first minute and add successively the changes in the speed of the motor and in the ammeter readings. He should be busy with all three tasks by the middle of the third minute.

In observing, the psychologist needs to attend as constantly as possible to the behavior of the reactor. The labor of recording must therefore be reduced to a minimum. For this purpose and for the purpose of standardizing the method of observation the following symbols have been adopted.

Symbols and their significance

M First significant effects on "voluntary muscular coördination."

♀ "Fumbling;" clumsiness; inaccuracy in touching the contact buttons.

? "Groping," approaching contact buttons with corrective movements.

E "Effort," increase in the force of applying the stylus to contact buttons.

$\exists$ Decreased "Effort."

I Impulsive or uncontroled movements.

(a) On the movement to the buttons.

(b) On the movement from the buttons.

S Slowing of reactive movements.

F Speeding of reactive movements.

^{A} First significant effects on "Attention."

dl "Distraction" from lights, neglects lights.

$dl\text{-}_{V}$ Neglects lights for ammeter.

/ Reactor delays initiating stylus movement so long that he fails to light check lamp.

// Reactor delays so long that he touches the button after the stimulus lamp has gone out.

/// Reactor starts movement after the light has gone out.

d_{V} "Distraction" from the ammeter dial, fails to note and adjust the position of the pointer.

d_{N} "Distraction" from the motor, neglects to control the speed of the motor.

|cl| Confusion between rows of lamps, but finally touches the right button.

$\underline{\overline{cl}}$ Confusion between columns of lamps, but finally touches the right button.

|wl| Selects button in wrong row.

$\underline{\overline{wl}}$ Selects button in wrong column.

W_{V} Moves ammeter pointer in wrong direction.

W_{N} Shift of pedal without change in motor speed.

Two of the symptoms, ♀, ?, I, and E repeatedly.

Two of the symptoms, dl, d_{V}, d_{N}, ///, cl, wl, and W_{V}.

"Inefficiency." Inability to control any of the three tasks. The reactor sometimes stares at the lights without making an attempt to touch a button, or makes a number of irrelevant touches. Completely disregards the motor and the ammeter. Sometimes severe tremors appear and jerkiness sets in finally.

* Breakdown. The reactor ceases to work and commences to collapse; qualitatively a more serious condition than

× Reactor released from the apparatus.

There are the following additional symbols for special diagnostic purposes:

〰 Tremor of the hand.
^^^ Jerkiness of the hand.
H Swaying or drooping of the head.
T Tapping buttons more than once.
R Rests hand or fingers in touching button.
K Keeps stylus on button after making touch.

The Bagby-Ross rating scheme

The aviator is rated, or classified, according to the following scheme.

1. Take twenty-five minutes as the standard duration of a run. If © or * appears before the end of twenty-five minutes, debit or credit one (1) point for each minute. Similarly, credit one point for each minute in case © or * appears after twenty-five minutes.

2. Assume, as a standard altitude, 7 per cent of oxygen for ©. Debit or credit one point for each one-tenth of 1 per cent.

3. As in the case of no. 1 above, take twenty-five minutes as the standard time for the appearance of both of the diamonds. Debit or credit one point for each minute.

4. Assume fifteen minutes for the standard time for the appearance of the two arrowheads. Debit or credit one-half point for each minute.

5. Add the debits and credits, and assign to classes as follows:

+ n	0	Class A
0	−12	Class A
−12	−30	Class B
−30	− n	Class C

In case the run is interrupted before © is reached, a computation, based on the above rating scheme, can be made assuming the missing symbols to have occurred at the time of ×.

At first glance the method of classification just described seems to be based on time rather than on oxygen percentage, but this is only apparent. If every reactor were run at the same

rate (a rate of oxygen depletion at which 7 per cent oxygen would be reached in 25 minutes), it would be immaterial whether the oxygen percentages or the times at which the v_s, $\diamondsuit_s$, and $©_s$ were reached should be used in the rating, since there would be a fixed correspondence between these. Since the rates of oxygen depletion vary in accordance with the individual rates of oxygen consumption, and since a faster rate enables the reactor to reach a lower percentage, it is necessary to make allowance for the variations in the rate of oxygen consumption.

This can be done by computing in oxygen percentages, and then making a correction for time, or more simply, as in the scheme actually employed, by computing in times, as if the oxygen change followed a line of the same slope in each case, and then correcting for deviation from this slope in terms of the final percentages of oxygen reached.

At the present time the standard rebreathing test has been administered to over seven thousand aviators. Almost a score of psychological observers have had opportunity to verify the effect of oxygen depletion as revealed by the preliminary investigation reported in part I of this report.

VITA

English Bagby was born in Baltimore, Maryland, May 9, 1891. After preliminary training at the Boys' Latin School, he entered Princeton University in the autumn of 1909 where he was graduated with the degree of Bachelor of Arts in 1913. The degree of Master of Arts was awarded by the same institution one year later. During the session 1914–1915 he taught at the Richmond Academy, Richmond, Virginia, returning the following year to Princeton University for further graduate study.

On July 1, 1916, he entered the Johns Hopkins University, remaining there until June, 1918, at the end of which period he entered the military service acting as Psychological Examiner of Aviators under the direction of the Surgeon General of the Army.

He was appointed Adjunct Professor of Psychology at the Virginia Military Institute in July, 1919, which position he has held to the present time.

April, 1920.